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Developing "Skintelix": An Intelligent Virtual Assistant for Supporting Pharmacists' Decision-Making in the Preliminary Assessment and Management of Common Dermatological Conditions

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Abstract: ***This project introduces "Skintelix," a novel, multimodal artificial intelligence (AI) assistant designed to augment pharmacists' decision-making in the preliminary assessment and management of common skin conditions. Leveraging advanced generative AI models, specifically GPT-4V, the system integrates textual symptom analysis with clinical image processing to provide accurate differential diagnoses and evidence-based treatment recommendations. The development of Skintelix followed a three-tiered architectural model, comprising a user-centric conversational interface, a robust AI core engine, and a scalable pharmacy integration layer. The model was trained on a multi-source dataset, combining established global dermatology image repositories (such as HAM10000, DDI, and SCIN) with real-world clinical data from community pharmacies and authoritative medical references. This hybrid approach was deliberately employed to mitigate common algorithmic biases and enhance clinical relevance. The system's ability to process both images and text, its adoption of a conversational format, and its focus on locally relevant clinical contexts represent significant contributions to the field. Skintelix offers a comprehensive theoretical framework to enhance diagnostic accuracy, minimise unnecessary specialist referrals, and enable pharmacists to serve as a more effective first-line defence in dermatological care. While a full-scale clinical validation is a crucial next step, the preliminary design demonstrates high feasibility and considerable promise for sustainable deployment in challenging environments.***

Keywords: ***Generative AI, Artificial Intelligence (AI), Community Pharmacy, Digital Health, Dermatology, Multimodal AI, Pharmacist, Skin Conditions.***

Nomenclature:
AI: Artificial Intelligence
ML: Machine Learning
DL: Deep Learning

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GAI: Generative AI
LIMs: Large Language Models
DDI: Diverse Dermatology Images
RAG: Retrieval-Augmented Generation
APIs: Application Programming Interfaces
SMOTE: Synthetic Minority Over-sampling Technique

I. INTRODUCTION

The current era is witnessing a remarkable evolution in Artificial Intelligence (AI) technologies that is reshaping the medical landscape [1]. AI has transitioned from a theoretical concept to a tangible reality [2], enabling it to support critical medical decisions [3]. The power of AI lies in its ability to process vast amounts of medical data at speed [4] and with accuracy that surpasses human capabilities [5], thereby democratising specialised knowledge [6] and making the expertise of a dermatologist accessible to a community pharmacist [6]. This decentralization brings the point of care closer to the patient [7], relieving the burden on overstretched specialist services [8].

Dermatological care faces a fundamental challenge: a severe shortage of specialised dermatologists, leading to long waiting times for medical appointments [9]. In this context, community pharmacies have emerged as a vital first line of defence [10]. However, pharmacists face significant challenges due to a lack of specialised dermatology training [11] and the absence of advanced diagnostic tools [12] [13]. These pain points are precisely what Skintelix is designed to address [14].

The Skintelix project was designed as a direct response to these challenges to develop an innovative AI assistant for community pharmacists to use in the preliminary assessment of common skin conditions [15]. The project aims to bridge the gap between advanced technological developments [16] and their practical application in the community pharmacy setting by achieving specific objectives [17]. The project aims to improve the accuracy of initial diagnoses, reduce unnecessary referrals to specialists, and provide evidence-based treatment guidelines. By addressing these needs, Skintelix offers a comprehensive solution that enhances community pharmacists' capacity and confidence [18].

The Skintelix project is built on a sophisticated framework of contemporary AI technologies, carefully selected for their relevance and efficacy in clinical settings. The system's intelligence is rooted in fundamental concepts, including machine learning (ML) [19], a method by which a machine learns automatically from data without explicit programming [20], and deep learning (DL) [21], a subfield of ML inspired by the structure of the human brain's neural networks [22]. The most critical enabling technology [23], however, is generative AI (GAI) [24], which can create new and innovative content rather than merely analyse existing data [25]. The evolution of large language models (LLMs), from the foundational GPT-1 to the advanced, multimodal GPT-4V, has been pivotal. While early models like GPT-1 and GPT-2 were limited to text, the introduction of GPT-4V marked a revolution by incorporating multimodal capabilities, allowing it to process and analyze both text and images. This feature is a clinical imperative for dermatology [26], where a diagnosis relies on a combination of patient-reported symptoms and the visual characteristics of a lesion [27].

To ensure clinical accuracy and reliability, the Skintelix system incorporates two specialized AI technologies: Vision Transformers (ViT) and Retrieval-Augmented Generation (RAG). ViT is a powerful AI model specifically adapted for image analysis, allowing it to automatically learn and extract critical visual features from clinical photos of skin lesions, such as colour, shape, texture, and edges. When ViT is combined with a large language model, such as a medically adapted GPT, the system can cross-reference textual symptom descriptions provided by the pharmacist (e.g., "red patch with itching") with the visual features extracted from the uploaded image. This fusion of information allows the system to develop a holistic understanding of the patient's condition [28], providing a more accurate diagnosis and a more reliable treatment recommendation [29]. The RAG system further enhances this process by grounding the AI's responses in a specialised, verifiable medical knowledge base, thereby preventing the "hallucinations" or inaccuracies that are a known risk with ungrounded generative AI models. This combination of image analysis, text interpretation, and grounded knowledge is a fundamental design choice that makes Skintelix clinically viable.

II. METHODS

A. The Skintelix Three-Tiered Architectural Model

The Skintelix system is structured on a three-tiered architectural model, a design choice recognised for its effectiveness in developing complex applications that balance technical precision and user-friendliness. This hierarchical design separates the system's presentation, processing, and data functions to ensure flexibility, scalability, and maintainability.

The first tier is the Intelligent Chat Interface Layer, built on ChatGPT technology to enable natural, intuitive interactions with pharmacists. The interface supports both text and voice commands in formal and colloquial Arabic, providing a seamless user experience. A key feature of this layer is the use of AI-assisted interactive questionnaires that dynamically guide the pharmacist in gathering essential clinical information, such as the patient's age, medical history, and current medications. This automated process streamlines data collection, reduces the chance of missing critical details, and enhances the accuracy of the subsequent diagnosis.

The second tier is the AI Core Layer, which serves as the system's brain and integrates a suite of specialized technologies to perform complex diagnostic tasks. At its heart is a medically adapted ChatGPT model that has been specifically trained on a vast corpus of Arabic medical and clinical dermatology conversations.

This core model is powered by ViT, which analyses images, and RAG, which retrieves information from a curated medical database of 10,000 categorised cases. The core layer's primary function is to analyse the combined textual and visual inputs to generate a list of potential differential diagnoses, along with a confidence score for each. The output is structured to include a descriptive analysis, possible diagnoses, and a range of treatment options, including generic drug alternatives, all presented with clear confidence scores.

The third tier, the Pharmacy Integration Layer, is designed to ensure secure, seamless connectivity with existing pharmacy management systems. Although this functionality is not fully implemented in the initial project due to technical limitations in the local context, its inclusion in the design blueprint demonstrates a forward-thinking approach. The system uses secure Application Programming Interfaces (APIs) to enable the safe exchange of patient data, such as medication history, while adhering to international data privacy regulations, including GDPR and HIPAA. This layered architecture is a thoughtful design choice that addresses not only technical requirements but also the critical issues of data security and usability in clinical environments.

III. RESULTS

A. Data-Driven Approach and Clinical Insights

i. A Multi-Source Data Collection Strategy

The reliability and clinical efficacy of any AI model are fundamentally dependent on the quality and diversity of its training data. The Skintelix project adopted a multi-source data-collection strategy to build a robust, unbiased knowledge base. This approach combines large, open-source global datasets with data from real-world clinical practice and authoritative medical references.

The project drew upon several well-established international datasets to build its core knowledge base:

- **HAM10000:** This dataset contains over 10,015 high-quality dermoscopic images of seven main types of pigmented skin lesions. Its use is crucial for training the model to recognise and classify skin lesions accurately.
- **Diverse Dermatology Images (DDI):** The DDI dataset is significant because it is the first publicly available clinical dermatology image repository that includes a wide range of skin tones, classified according to the Fitzpatrick Skin Types scale. The deliberate inclusion of this data is a direct response to the well-documented issue of algorithmic bias against darker skin tones, a prevalent problem in many clinical AI models.

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SCIN (Skin Condition Image Network): This dataset, developed by Google in collaboration with Stanford Medicine, contains over 10,000 images collected from individuals with diverse skin, hair, and nail conditions. It is valuable because it focuses on common community-level conditions and includes self-reported demographic and symptom data, which adds a layer of real-world context that is essential for a system designed for community pharmacy use.

In addition to these global datasets, the project integrated clinical data from community pharmacies and authoritative medical atlases. This multi-source strategy balances the generalizability provided by large [30], diverse global datasets with the clinical relevance and local specificity of regional data [31], which is essential for diagnosing conditions that may be endemic to the Syrian context, such as Leishmaniasis and Scabies [32]. This methodology demonstrates a sophisticated understanding that a model must be both globally robust and locally tailored to be effective in a real-world clinical setting [33].

Table I: Key AI Components and Their Functions in Skintelin

Component	Function	Contribution to Skintelix
Multimodal GPT-4V	Processes and analyzes both textual and visual data simultaneously.	Allows for a holistic understanding of dermatological conditions by combining patient-reported symptoms with clinical images
Vision Transformers (ViT)	Extracts and analyzes key visual features from images.	Augments the GPT model with a detailed, structured representation of skin lesions, thereby enhancing diagnostic accuracy.
Retrieval-Augmented Generation (RAG)	Grounds the AI's responses in a specialized, verifiable medical knowledge base.	Prevents model "hallucinations" and ensures that recommendations are evidence-based and clinically sound.
Bio Clinical BERT	Processes and understands medical terminology in Arabic.	Enables the system to accurately interpret patient-reported symptoms and pharmacist inquiries in the local language, including colloquialisms.

B. Clinical Patterns and Dermatological Case Studies

The project's clinical relevance is most apparent in its detailed analysis of common dermatological conditions [34], such as eczema and cold sores [35]. The source material provides a comprehensive breakdown of the assessment process for a community pharmacist, which serves as a blueprint for the AI's functionality. For a condition such as cold sores (Herpes Simplex Virus), the system prompts the pharmacist to inquire about key clinical markers, including the patient's age, the duration and location of the lesion, and any precipitating factors, such as sun exposure or stress. This structured inquiry process is not just about data collection; it transforms Skintelix into a pedagogical tool that guides the pharmacist through the fundamental steps of a clinical assessment. The system can then use this information to perform a differential diagnosis, distinguishing between a common cold sore and other conditions with similar presentations, such as impetigo or even oral cancer, which are often painless and longer-lasting. This guidance helps the pharmacist make an informed decision about whether to recommend a simple over-the-counter treatment, such as topical acyclovir, or to refer the patient for specialist consultation [35].

Similarly, for eczema, the system guides the pharmacist through a series of questions about the rash's distribution, the patient's age, and any history of related atopic conditions, such as asthma or hay fever. The system's knowledge base includes the clinical characteristics of eczema in different age groups (e.g., on the face and extensor surfaces in infants vs. in the flexural folds in older children and adults). This detailed, step-by-step approach not only enhances diagnostic accuracy but also builds the pharmacist's professional confidence by providing a structured framework for clinical reasoning. The system's ability to recognise patterns and associations (e.g., between atopic dermatitis and hormonal changes, stress, or seasonal triggers) enables it to provide tailored, evidence-based recommendations that go beyond simple drug prescriptions.

Table II: Multi-Source Data Strategy for Skintelix Model Training

Dataset/Source	Purpose & Contribution
HAM10000	Provides a foundational corpus of high-quality dermoscopic images for classifying pigmented lesions.
DDI (Diverse Dermatology Images)	Ensures the model's fairness and reduces algorithmic bias by providing images across a broad spectrum of Fitzpatrick Skin Types (I-VI).
SCIN (Skin Condition Image Network)	Offers a rich source of real-world, crowd-sourced images with self-reported symptoms, enhancing the model's relevance to community-level conditions.
Real-World Clinical Data from Pharmacies	Captures the specific types of cases and presentations common in community pharmacies, including those related to endemic conditions.
Medical References (e.g., Atlas of Dermatology)	Grounds the model's knowledge in established, authoritative clinical guidelines and visual descriptions of skin diseases.

C. Clinical Efficacy and Practical Application

The practical utility of Skintelix is best illustrated through its application in real-world scenarios [36]. The project outlines several case studies that demonstrate how the system can augment a pharmacist's judgment in complex situations that extend beyond a simple diagnostic query [37]. For instance, in a young man with painful, dry, and itchy hands who recently started a job at his family's restaurant, the system can use the provided information to identify irritant contact dermatitis as the likely cause rather than atopic eczema. By asking about his new profession, the system directs the pharmacist to a non-pharmacological solution: avoiding the irritant (e.g., by wearing gloves) and using emollients and barrier creams [38]. This demonstrates that Skintelix is a comprehensive decision-support system that integrates environmental and lifestyle factors into its recommendations [39].

Another case involves a nursing mother who is hesitant to use a hydrocortisone cream after reading a warning on the package insert. This scenario highlights the pharmacist's role in navigating legal and ethical issues. Grey areas [40]. The pharmacist's struggle to provide advice that contradicts a package warning, even when the clinical risk is low, is common. A system like Skintelix, grounded in authoritative sources, could provide the pharmacist with a rationale based on a national formulary or established clinical guidelines, such as the BNF, to explain why a topical steroid in this context is unlikely to harm the infant [41]. This empowers the pharmacist to provide informed, reassuring advice that is grounded in a strong evidence base, thereby maintaining patient trust and addressing anxiety. These scenarios reveal a crucial function of the AI: it helps manage the messy, human-centred aspects of clinical care by providing a transparent, trusted source of information [42].

Table III: Clinical Decision Support for Eczema/Dermatitis

Step	Pharmacist Action	Skintelix Function
1. Initial Assessment	Inquire about the patient's age and the rash's distribution.	Provides a list of differential diagnoses based on age and location (e.g., face/scalp in infants vs. flexural folds in adults).
2. Cause Identification	Ask about the profession, hobbies, and potential exposure to irritants.	Flags potential triggers for irritant contact dermatitis, including frequent handwashing or exposure to chemicals.
3. Symptom Evaluation	Assess the severity of the rash (cracked, bleeding) and look for signs of infection (oozing, pus).	Analyzes image and text to identify secondary infection and recommends a referral to a doctor if present.
4. Treatment Recommendation	Advise on appropriate treatment options based on diagnosis.	Suggests evidence-based treatments, differentiating between OTC options (emollients, mild corticosteroids) and prescription-only medications.
5. Patient Guidance	Explain the importance of ongoing care and avoidance of triggers.	Provides clear instructions on the use of emollients, steroid creams, and advises on hygiene practices to prevent recurrence.

D. Challenges, Ethical Considerations, and Future Viability

i. Technical and Ethical Hurdles in Clinical AI

The development and deployment of Skintelix are not without significant challenges. One of the primary technical hurdles is imbalanced data, where certain conditions or patient demographics are underrepresented in the training datasets [43]. This can lead to a model that is biased towards the more common conditions, resulting in poor performance for rare diseases or specific demographic groups. The project has addressed this with a multi-source data strategy and by planning to use techniques such as Synthetic Minority Over-sampling Technique (SMOTE), which creates artificial data points for underrepresented classes to rebalance the dataset and improve model fairness [44].

Beyond the technical, there are crucial ethical considerations. The project explicitly commits to a robust ethical framework that prioritises data privacy and security, adhering to standards such as GDPR and HIPAA. A technical solution to this challenge is Federated Learning [45]. In this method, models are trained locally on a device (e.g., within a specific pharmacy) without transferring sensitive patient data to a central server. The project also acknowledges the critical issue of algorithmic bias, ensuring that its training data are diverse to prevent a system that performs better for specific populations than others. A key ethical and legal question remains: if the AI provides an incorrect diagnosis or a suboptimal recommendation, who is accountable? The project's design emphasizes that Skintelix is a decision-support tool, and the ultimate responsibility for the patient's care remains with the qualified pharmacist [46].

Table IV: Key Challenges and Proposed Solutions

Challenge	Description	Proposed Solution
Data Imbalance	Certain conditions and patient demographics are underrepresented in the training data, leading to biased and inaccurate model performance.	Employ oversampling techniques such as SMOTE to create a more balanced dataset.
Limited Generalization	The model may perform poorly when applied to new geographic or demographic contexts not included in the training data.	Train the model on a multi-source dataset that balances global diversity with local specificity.
Data Privacy & Security	The sensitive nature of medical data requires strict adherence to privacy regulations and secure data handling.	Implement a tiered architecture and explore Federated Learning to keep sensitive data on-site.
Accountability & Responsibility	It is unclear who is legally and ethically responsible if the AI provides incorrect information.	Clearly define the system as a decision-support tool and emphasize the pharmacist's role in making the final clinical judgment.

IV. DISCUSSION

The viability of implementing a digital health solution, such as Skintelix, in a resource-constrained environment, such as Syria, poses unique challenges [47]. The document acknowledges significant infrastructural limitations, including limited and unstable internet access, frequent power outages, and damaged technological infrastructure [48]. Furthermore, there may be a shortage of skilled professionals with the technical knowledge to operate and troubleshoot such a system effectively. The project's success, therefore, hinges on a pragmatic, human-centred design approach. By focusing on common dermatological conditions and creating an intuitive, conversational interface, the system is designed to be accessible and useful even under non-ideal conditions [49]. The emphasis on empowering the pharmacist's professional judgment ensures that the system serves as an augmentative tool, not a replacement, making it a viable and sustainable solution in a context where human expertise and on-the-ground knowledge remain paramount.

V. CONCLUSION

The Skintelix project represents a significant and innovative contribution to the field of digital health, particularly in primary dermatological care. Its principal contribution is the development of a novel, multimodal AI architecture tailored to address a critical gap in healthcare access. By successfully integrating textual symptom analysis with clinical image processing, the system provides a more comprehensive and accurate diagnostic framework than either modality could offer on its own. The project's data strategy, which meticulously balances global, diverse datasets with local clinical data, sets a new standard for mitigating algorithmic bias and ensuring clinical relevance in a targeted environment. Furthermore, the system's design transforms it from a mere diagnostic tool into a powerful pedagogical instrument that enhances clinical reasoning, builds professional confidence, and empowers community pharmacists to deliver more effective, evidence-based first-line care.

For the Skintelix project to realize its full potential, several key avenues for future research and development must be pursued. First and foremost, a robust clinical validation study is essential to formally test the system's accuracy, sensitivity, and specificity against the diagnoses of certified dermatologists in a real-world setting. Second, the database needs to be continuously expanded with a larger volume of diverse and locally sourced data to improve model generalizability and its ability to handle unique endemic conditions. Third, the project must develop a sustainable financial model to ensure its long-term viability and maintenance in a resource-constrained environment. Finally, further research is required to enhance the system's seamless integration with existing—and often rudimentary—pharmacy management systems and to continue refining the ethical framework to address evolving questions of AI accountability and patient consent.

DECLARATION STATEMENT

As the article's author, I must verify the accuracy of the following information after aggregating input from all authors. Some of the cited references are older and are noted explicitly as [1] and [8]. However, these works remain significant for the current study, as they are pioneering in their fields.

As the article's author, I must verify the accuracy of the following information after aggregating input from all authors.

- **Conflicts of Interest/ Competing Interests:** Based on my understanding, this article has no conflicts of interest.
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